(19) THE FEDERAL REPUBLIC OF GERMANY

/Emblem/

THE GERMAN PATENT- AND TRADEMARK OFFICE

(12) **Patent Disclosure**

(10) **DE 199 62 711 A 1**

(51) Int. Cl.[7]: B 25 C 1/08

(21) File reference: 199 62 711.8

(22) Application date: 12 23 1999

(43) Disclosure date: 07 05 2001

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(58) Citations:

DE 40 32 201 A 1

The following statements are taken from documents submitted by the applicant.

A request for examination in accordance with 44 PatG [/= Patent Law/] has been filed.

(54) **A movable, combustion-operated operating tool with changeable precombustion chamber.**

(57) The invention relates to a movable, combustion-operated operating tool, particularly a placing device for attachment elements. It contains a combustion chamber (1) between a combustion chamber base wall (3) and a combustion chamber wall (14) lying opposite to it, as well a movable separating plate (18), lying between these walls (3, 14) and having penetrating apertures (38), [which separating plate (18) is] for the formation of a precombustion chamber (21) between it and the combustion chamber wall (14). An adjusting device serves for changing the distance between the combustion chamber wall (14) and the separating plate (18), so that a desired combustible gas mixture can be adjusted in the precombustion chamber (21) through the selection of the position of the separating plate (18) relative to the combustion chamber wall (14).

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/Form reference/: Federal German Printing Office - 05.01 - 102 - 027/777/1 - 13

Description

The invention relates to a movable, combustion-operated operating tool, particularly a placing device for attachment elements. The operating tool contains a combustion chamber between a combustion chamber base wall and a combustion chamber wall lying opposite to it, as well a movable separating plate, lying between these walls and having penetrating apertures, [which separating plate is] for the formation of a precombustion chamber between it and the combustion chamber wall. A primary chamber, from which still further precombustion chambers can be separated, if so desired, by means of additional separating plates, is located between the combustion chamber base wall accommodating a piston plate and the separating plate. The combustion chamber is, preferably, cylindrically formed.

The driving energy in operating tools of the type stated is provided by means of the internal combustion of a combustible gas mixture, such as a mixture of air / combustible gas, for example, which is conveyed, by means of a piston, to an attachment element which is to be driven into an object. The combustible gas mixture is thereby possibly provided, in different mixture ratios, in all of the partial combustion chambers of the combustion chamber. For the sake of simplicity, a combustion chamber which is only divided into a precombustion chamber and a primary chamber will be considered here.

The combustion is started in the precombustion chamber by means of an electrical spark produced by an ignition device, and a flame front begins to radially diffuse at relatively slow speed. It thereby pushes uncombusted gas forward in front of it, which thus flows through the penetrating apertures in the separating plate and enters into the primary chamber in order to produce turbulence as well as precompression. If the flame front reaches the penetrating apertures to the primary chamber, then the flames, caused by the constriction of the cross-section, cross over into the primary chamber as jets of flame and produce turbulence here. The thoroughly-mixed turbulent combustible gas mixture in the primary chamber is then ignited over the entire surface of the jets of flame. It burns at a high speed, which leads to a sharp increase in the level of efficiency of combustion, since the cooling losses remain small.

The task which forms the basis of the invention is that of being able to regulate the release of energy of the operating tool.

The solution of the task set is stated in the characterizing portion of patent claim 1. Advantageous configurations of the invention are to be derived from the sub-claims.

The operating tool in accordance with the invention is characterized by the fact that it has an adjusting device, by means of which the distance between the combustion chamber wall and separating plate can be changed.

By means of this adjusting device, the volume of the precombustion chamber or Adams chamber can be changed with the total volume of the combustion chamber still remaining the same, in order to obtain a richer or leaner combustible gas mixture in the precombustion chamber by that means. It is consequently possible to change the combustible gas mixture in the direction of rich or lean, in a simple manner, in dependence on the ambient temperature and the ambient pressure, in order to improve the reliability of ignition of the operating tool, particularly at low temperatures and/or lower air density upon working levels.

Through the change of size of the precombustion chamber, the size of the primary chamber is also changed, as is the pressure gradient in the precombustion chamber as well as the course of combustion in the precombustion chamber, the level of the precompression in the primary chamber, the level of the turbulence produced in the primary chamber, and the energy losses through the cooling off of the burning combustible gas mixture, so that the energy to be used by the operating tool can be adjusted within wide ranges, and can be adjusted to desired working conditions or environmental conditions.

In accordance with one configuration of the invention, the adjusting device has an adjusting element stressing the separating plate, which is held on the edge or centrally at a distance above the combustion chamber, for example, and can be displaced into the axial direction of the combustion chamber. The adjusting element can preferably be an adjusting screw, through the rotation of which the distance between the combustion chamber and the separating plate can be consequently changed. The adjustment of the combustible gas mixture in the combustion chamber can consequently be carried out manually and relatively quickly, which improves the ease of use of the operating tool.

The adjusting element can thereby be held by a support element overlapping the combustion chamber wall, which can be formed in the shape of a circular plate, for example. A simple positioning of the adjusting element, and thereby a simple mechanical construction, which has a cost-favorable effect on the manufacturing of the operating tool, is consequently guaranteed.

The support element can, in accordance with an additional configuration of the invention, be held on the inner wall of the combustion chamber, such as by being screwed into the frontal side of the cylindrical

combustion chamber, for example. An extension of the separating plate, which lies centrally to it, for example, can thereby project through the combustion chamber wall and can be stressed by the adjusting element.

A pressure spring -- which is supported on the combustion chamber wall and tends to press the extension into the direction towards the adjusting element so that, in this manner, the adjustment of the separating plate can be carried out relative to the combustion chamber wall, even without clearance, which makes possible an exact adjustment of the volume of the precombustion chamber -- lies between the free end of the drive rod and the combustion chamber wall.

It is possible, in principle, to provide the combustion chamber, which is preferably constructed cylindrically, with solid front walls and thus with a stationary combustion chamber base wall and combustion chamber wall which is stationary and positioned opposite to it. In such a case, only the separating plate would then be able to be moved in the axial direction of the combustion chamber.

It is also possible to form the combustion chamber as a collapsible system, however. In such a case, the combustion chamber wall could additionally be entrained in the axial direction or the cylinder longitudinal direction of the combustion chamber, and thereby entrain the separating plate. The collapsed condition of the combustion chamber would be achieved if the separating plate comes to lie on the combustion chamber base wall, and the combustion chamber wall [comes to lie] on the separating plate. Upon the movement of the combustion chamber wall in the reverse direction, away from the combustion chamber base wall, therefore, the combustion chamber wall would entrain the separating plate again, and the partial combustion chambers would be loaded again. An adjustment of the distance between the combustion chamber wall and the separating plate through the adjusting device would then be possible, for example, if the separating plate entrained by the combustion chamber is acted on by the adjusting element again.

The movement of the base wall away from the combustion chamber base wall is restricted by a catch unit which is formed by the support element, for example. The support element can thereby be adjustable in the axial direction of the combustion chamber, in order to additionally to be able to change the overall volume of the combustion chamber in the event that this is desired.

An example of implementation of the invention will be illustrated in further detail in the following with reference to the single diagram.

The figure depicts an axial section through a combustion-operated placing device for attachment elements in the area of its combustion chamber, which is formed here as a collapsing combustion chamber. The placing device has a cylindrically-formed combustion chamber (1) with a cylinder wall (2) and an annular base wall (3) connecting to the same. An aperture (4), with which a guide cylinder (5) is connected, which [guide cylinder] has a cylinder wall (6) and a base wall (7), is located in the center of the base wall (3). Inside the guide cylinder (5), a piston (8) is supported displaceably in a sliding manner and, specifically so, in the longitudinal direction of the guide cylinder (5). The piston (8) consists of a piston plate (9), which points towards the combustion chamber (1), as well as a piston rod (10) centrally connected with the piston plate (9), which [piston rod] partially projects out from the guide cylinder (10) through a penetrating aperture (11) in the base wall (7).

In the figure, the piston (8) is in its retracted resting position. The side of the piston plate (9) oriented towards the combustion chamber (1) is more or less sealed off with the interior side of the base wall (3), and the piston rod (10) projects only slightly outwardly over the base wall (7). Sealing rings (12) can be provided on the external circumference of the piston plate (9), in order to seal off the spaces on both sides of the piston plate (9) against one another.

A cylinder plate (14), which can be termed a movable combustion chamber wall, is located inside the combustion chamber (1). The combustion chamber wall (14) is displaceable in the longitudinal direction (X) of the combustion chamber (1) and has an annular sealing unit on its external circumferential edge in order to seal off the spaces in front of and behind the combustion chamber wall (14). Furthermore, the combustion chamber wall (14) has a central penetrating aperture (16) with an annular circumferential sealing. An additional separating plate (18) is located between the combustion chamber wall (14) and the base wall (3). The separating plate (18) is likewise formed in a circular manner and has an external diameter which corresponds to the internal diameter of the combustion chamber (1). On the side pointing to the combustion chamber wall (14), the separating plate (18) is connected with a cylindrical extension (19), which projects through the central penetrating aperture (16) of the combustion chamber wall (14) and the length of which corresponds to a multiple of the thickness of the combustion chamber wall (14). The circumferential sealing along the edge of the penetrating aperture (16) is thereby tightly joined with the external circumferential surface of the cylindrical extension (19). On its free end, the cylindrical extension (19) has an annular extension (20) projecting over its circumference. The external diameter of the annular extension (20) is greater than the internal diameter of the penetrating aperture (16). A pressure spring (15) which tends to always press the separating plate (18) in the direction

towards the combustion chamber wall (14) is located between the annular extension (20) and the side of the combustion chamber wall (14) oriented to it.

For the displacement of the combustion chamber wall (14) in the longitudinal direction of the combustion chamber (1), three drive rods (23), for example, only one of which is to be seen in the diagram, are solidly connected with the combustion chamber wall (14), being distributed at equal angular distances over its circumference. The drive rods (23) lie in parallel to the cylinder axis of the combustion chamber (1) and externally laterally to the cylinder wall (6). The drive rods (23) thereby each pass through a penetrating aperture (24) in the separating plate (18), as well as an additional penetrating aperture (25) in the base wall (3). Another internal-side circumferential sealing for sealing off of the spaces on both sides of the base wall (3) is located there. The drive rods (23) and the combustion chamber wall (14) are connected with one another by means of screws (27), for example, which are guided through the combustion chamber wall (14) and are screwed into the drive rods (23) on the frontal side. The free ends of the drive rods (23) are connected with one another by way of a drive ring (28), which lies concentric to the cylinder axis of the combustion chamber (1) and encompasses the guide cylinder (5). The drive ring (28) can thereby be bolted with the drive rods (23) by means of screws (29) in such a manner that the screws (29) pass through the drive ring (28) and are screwed into the free frontal sides of the drive rods (23). On each of the drive rods (23), a pressure spring (30), which is supported on the outer side of the base wall (3) and presses the drive ring (28), lies between the drive ring (28) and the base wall (3). The pressure spring thereby tends to always press the combustion chamber wall (14) in the direction towards the base wall (3).

A ventilating- / evacuating valve (31) is additionally located in the area of the annular base wall (3). This is only indicated schematically. As will be described further below, this valve (31) serves to supply fresh air into the combustion chamber (1), as well as to expel combusted residual gases from the combustion chamber (1). In the operating condition of the operating tool indicated in the figure, shortly before the ignition of the combustible gas mixture in the combustion chamber (1), the ventilating- / evacuating valve (31) is held closed and, specifically so, by means of the drive ring (28). If it is distanced from the base wall (3), then the ventilating- / evacuating valve (31) makes a transition into the opened condition.

It should be additionally mentioned that the separating plate (18) has several penetrating apertures (38) on its circumference side, which [penetrating apertures] each have the same distance from the cylinder axis of the combustion chamber (1). Furthermore, exhaust apertures (39) for the outflow of

air from the guide cylinder (5) if the piston (8) is moved into the direction of the base wall (7) are positioned on the lower end of the guide cylinder (5). Furthermore, a damping device (40) for the damping of the movement of the piston (8) is located on the lower end of the guide cylinder (5). If the piston (8) passes beyond the exhaust apertures (39), then exhaust gas can escape from the exhaust apertures (39).

A support element (43) formed as a circular plate is located above the combustion chamber wall (14). This support element (43) is inserted into a circumferential groove (44) on the free end of the combustion chamber (1) and is secured there with the help of a locking ring (45) which is screwed, by means of its external threading, into a correspondingly-formed internal threading (46) of the combustion chamber (1). The support element (43) consequently forms a catch unit for the combustion chamber wall (14) upon the movement of the combustion chamber wall (14) in the direction away from the base wall (3). The support element (43) is, in addition, formed in a convex manner so that it has, in its center, a greater distance from the combustion chamber wall (14) than it does on its edge.

In the central area of the support element (43), this has a penetrating aperture (47) provided with an internal threading, into which [penetrating aperture] an adjusting screw (49) provided with an external threading (48) is screwed. It can be seen in the figure that, in the operating condition of the operating tool which is depicted there, the free end of the cylindrical extension (19) strikes against the free end of the adjusting screw (49) pointing downwardly. The pressure spring (15) thereby presses, by means of the annular flange (20), the free end of the cylindrical extension (19) in an upward direction against the adjusting screw (49) so that, upon the rotation of the adjusting screw (49) against the pressure of the pressure spring (15), the distance between the combustion chamber wall (14) and the separating plate (18) can be changed if the combustion chamber wall (14) strikes against the support element (43). In this way, the volume of the precombustion chamber (21) can be reduced or enlarged while, at the same time, the volume of the primary chamber (22) is either enlarged or reduced, as the case may be.

Another two radial penetrating apertures (41 and 42), which are spaced from one another in the axial direction, are located in the cylinder wall (2) of the combustion chamber (1). Outflow channels, not depicted, of dosing valves, also not depicted, through which fluid combustible gas, for example, can be injected into the partial combustion chambers (21 and 22) in a dosed manner, project from the outside into these penetrating apertures (41 and 42). In an alternative manner, combustible gas could also be supplied in a gaseous condition.

It should be additionally mentioned that the central extension (19) connected with the separating plate (18) is, in its area oriented towards the separating plate (18), formed as an ignition enclosure (51) for the accommodation of an ignition device (52). This ignition device (52) serves for the production of an electrical spark for the purpose of igniting a combustible gas mixture in the precombustion chamber (21). As will be described in further detail below, the ignition device (52) is located in the interior or in a central area of the ignition enclosure (51), which is provided, on its circumferential side, with penetrating apertures (53) through which a flame front can exit from the ignition enclosure (51) into the precombustion chamber (21).

The manner of action of the placing device will be described in further detail in the following.

If the placing device is in the resting position, then the combustion chamber (1) is completely collapsed, whereby the separating plate (18) is supported on the base wall (3) and the combustion chamber (14) [is supported] on the separating plate (18). The piston is located in its retracted resting position, so that practically no more space is present between it and the separating plate (18), if a slight gap between these is disregarded. The placing of the plates (18 and 14) on one another is brought about through the fact that the pressure spring (30) presses the drive ring (28) away from the base wall (3), and the drive ring (28) entrains the combustion chamber wall (14) by way of the drive rods (23). In this condition, the drive ring (28) also lies at a distance from the ventilating- / evacuating valve (31), so that this is opened.

If, in this condition, the placing device is pressed with its forward tip against an object into which an attachment element is to be driven, then the pressing force acts on the drive ring (28) by way of a mechanism which is not depicted (indicated in only rough terms as [50]) and displaces this in the direction towards the base wall (3) and, specifically so, with the pressing of the placing device against the stated object. The combustion chamber wall (14) is thereby moved away from the base wall (3) and, at the same time, entrains the separating plate (18), since the latter is pressed against the lower side of the combustion chamber wall (14) by means of the pressure spring (15). The system of combustion chamber wall (14) and separating plate (18) is consequently lifted up in common until the free end of the cylindrical extension (19) strikes against the lower end of the adjusting screw (49). By that means, the movement of the separating plate (18) away from the base wall (3) is blocked. The primary chamber (22) is now completely loaded. Upon the further displacement of the combustion chamber wall (14) in the stated direction, the pressure spring (15) and the combustion chamber wall (14) are finally moved against the support

element (43) acting as a catch unit and come to stop. The precombustion chamber (21) is now also completely loaded. The size of the precombustion chamber (21) can be adjusted, either now or at an earlier time, through the screwing or the unscrewing of the adjusting screw (49). Depending on the depth of screwing of the adjusting screw (49), a lesser or greater distance between the separating plate (18) and the combustion chamber wall (14) results and, consequently, also a correspondingly changed volume of precombustion chamber (21) and primary chamber (22) as well.

During the loading of the combustion chamber (1), air can already be suctioned into the primary chamber (22) and, specifically so, through the ventilating- / evacuating valve (31), which is still open in this condition. It also remains open during the further loading of the precombustion chamber (21), so that this can also be ventilated by means of the penetrating apertures (38). Shortly before the precombustion chamber (21) is completely loaded, the fluid gas is supplied through the penetrating apertures (41 and 42).

If the lever or trigger of the placing device is now activated, then an ignition spark is produced by the electrical ignition device (52) inside the ignition enclosure (51). Even before that, or shortly afterwards, the drive ring (28) is locked and can no longer be moved in the axial direction. The mixture of air and combustible gas preadjusted in each of the chambers (21 and 22) by means of dosing begins to burn, first of all, in the precombustion chamber (21), whereby the flame front diffuses radially, at a relatively slow speed, in the direction of the penetrating apertures (38). An uncombusted mixture of air / combustible gas, which passes through the penetrating apertures (38) into the primary chamber (22) and produces turbulence here as well as a precompression, is thereby displaced in front of it. If the flame front reaches the penetrating apertures (38) to the primary chamber (22), then the flames, caused by the relatively small cross-sections of the penetrating apertures (38), cross over, as jets of flame, into the primary chamber (22) and produce additional turbulence here. The thoroughly-mixed turbulent mixture of air / combustible gas in the primary chamber (22) is ignited over the entire surface of the jets of flame. It now burns at high speed, which leads to a great increase in the level of efficiency of the combustion.

The piston (8) is acted on by the combustion pressure and is moved at high speed into the direction of the base wall (7) whereby, at the same time, the air from the guide cylinder (5) is driven outwardly through the exhaust apertures (39). Within a short time, the piston plate (9) passes beyond the exhaust apertures (39), so that the exhaust gas can escape through this. An attachment element is now placed by the piston rod (10) moving out. After the placing, or after the completed combustion of the mixture of air / combustible gas, the piston (8) is brought back into its starting position by means of thermal

recovery, since an underpressure is produced behind the piston through the cooling off of the flue gas remaining in the combustion chamber (1) and in the guide cylinder (5). The combustion chamber (1) must remain tightly closed until the piston has reached its starting position in accordance with Figure 2.

After it has been guaranteed that the piston (8) has again reached its starting position depicted in Figure 2, the previously-mentioned locking of the combustion chamber wall (14) or of the drive ring (28) is ended. The pressure spring (30) now presses the drive ring (28) away from the base wall (3), so that the drive ring (28) relieves the ventilating- / evacuating valve (31), and this can be opened. Upon the further action of the pressure spring (30), the drive ring (28) is further removed from the base wall (3) and, by means of the drive rods (23), entrains the combustion chamber wall (14) in the direction towards the base wall (3). The pressure spring (15) first of all brings it about that the separating plate (18) is still not entrained so that, first of all, the precombustion chamber (21) collapses and is thereby evacuated of exhaust gases by way of the penetrating apertures (38) and the ventilating- / evacuating valve (31). Finally, the combustion chamber wall (14) also entrains the separating plate (18), if it strikes against this. The primary chamber (22) now begins to collapse, and it is freed of exhaust gases by way of the ventilating- / evacuating valve (31). Finally, the separating plate (18) comes to lie on the base wall (3), and the combustion chamber wall (15) [comes to lie] on the separating plate (18). The operating tool has now assumed its resting position.

Patent Claims

1. A movable, combustion-operated operating tool, particularly a placing device for attachment elements, with a combustion chamber (1) between a combustion chamber base wall (3) and a combustion chamber wall (14) lying opposite to it, as well a movable separating plate (18) lying between these walls (3, 14) and having penetrating apertures (38), [which separating plate is for] the formation of a precombustion chamber (21) between it and the combustion chamber wall (14), **characterized by** an adjusting device (49, 19), by means of which the distance between the combustion chamber wall (14) and the separating plate (18) can be changed.

2. An operating tool in accordance with claim 1, **characterized in that,** the adjusting device (49, 19) has an adjusting element (49) stressing the separating plate (18), which [adjusting element] is held at a distance above the combustion chamber wall (14) and is displaceable in the axial direction (X) of the combustion chamber (1).

3. An operating tool in accordance with claim 2, **characterized in that,** the adjusting element is an adjusting screw (49).

4. An operating tool in accordance with claim 2 or 3, **characterized in that,** the adjusting element (49) is held by a support element (43) overlapping the combustion chamber wall (1).

5. An operating tool in accordance with claim 4, **characterized in that,** the support element (43) is formed in the form of a circular plate.

6. An operating tool in accordance with claim 4 or 5, **characterized in that,** the support element (43) is held on the internal wall of the combustion chamber (1).

7. An operating tool in accordance with one of the claims 2 to 6, **characterized in that,** the adjusting element (49) is positioned centrally on the combustion chamber wall (14).

8. An operating tool in accordance with one of the claims 1 to 7, **characterized in that,** an extension (19) of the separating plate (18) projects through the combustion chamber wall (14) and can be acted on by the adjusting element (49).

9. An operating tool in accordance with claim 8, **characterized in that,** a pressure spring (15) is positioned between the free end of the extension (19) and the combustion chamber wall (14).

10. An operating tool in accordance with one of the claims 1 to 9, **characterized in that,** the combustion chamber wall (14) is displaceable in the axial direction (X) of the combustion chamber wall (1).

11. An operating tool in accordance with claim 10, **characterized in that,** the support element (43) forms a catch unit for the combustion chamber wall (14).

12. An operating tool in accordance with claim 11, **characterized in that,** the catch unit (43) is adjustable in the axial direction (X) of the combustion chamber (1).

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1 page(s) of diagrams follows.

Nummer: DE 199 62 711 A1
Int. Cl.⁷: B 25 C 1/08
Offenlegungstag: 5. Juli 2001